U.S. COAST GUARD

RADIONAVIGATION BULLETIN

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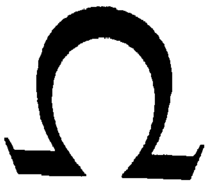

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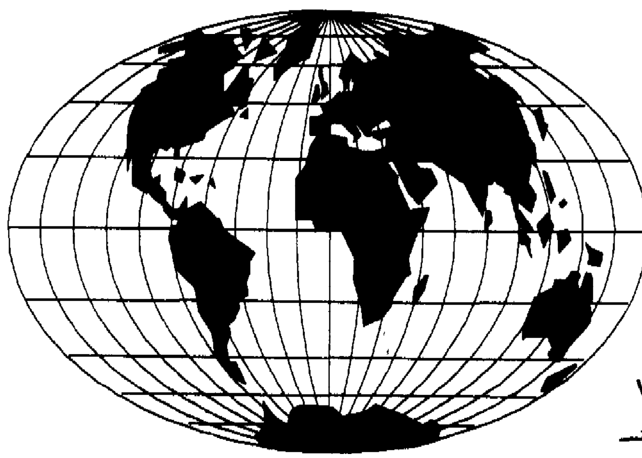

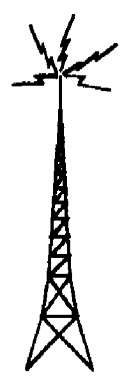

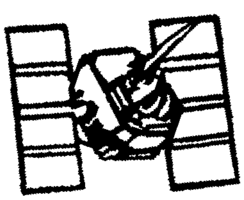

DGPS/GPS

RADIOBEACONS

OMEGA: TERMINATION

DGPS: ON THE WAY TO FOC

LORAN: CONSOLIDATION PROJECT

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RADIONAVIGATION BULLETIN

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From the Commanding Officer . . .

I was pleased with the response to the call for papers in the last edition of the Radionavigation Bulletin. I think you'll find a good selection in this one. Thanks; as long as we have interesting items to share, this Bulletin is a great place to publish them.

Let me discuss a few of the actions that have been keeping us busy at NAVCEN, and around the Coast Guard, these past few months. First, we've been gaining a lot of experience with the USCG's maritime DGPS service. At the end of January, the service completed a year of its Initial Operating Capability (IOC) phase. During this year, we've learned quite a bit about the capabilities and constraints of our equipment, procedures for operations and routine and emergency maintenance at these remotely located sites, and improvements required. We are in the process of designating LCDR Gary Schenk, DGPS Planning Branch Chief, as Project Officer to oversee upgrading the DGPS service to Full Operating Capability (FOC). During his project's "drive to FOC," we expect to upgrade transmitters, antennas, backup power systems, and receiver firmware and wiring; to operationally certify all site installations; to verify coverage and correct any identified deficiencies; and to upgrade and standardize operations and support procedures.

While on the subject of DGPS, I'd like to take a moment to boast about the USCG accomplishment with this service. It is the first nationwide augmentation of GPS in the United States, and in fact, it has become the model for worldwide maritime DGPS service. In the IOC phase, it fully meets an international maritime standard (RTCM SC-104), providing better than 10 meter accuracies and less than 10 second integrity notifications, throughout virtually all navigable waters of the United States. This has all been done with commercial off-the-self (COTS) components. There are currently 53 DGPS sites operating along our Atlantic, Pacific, Gulf of Mexico, and Great Lakes coasts, including Hawaii, Puerto Rico, and selected coastal areas of Alaska, and in partnership with the Army Corps of Engineers (ACOE), along the Mississippi River and tributary systems. Two more sites are planned with the ACOE to complete Missouri and Ohio River coverage, and a third is planned in partnership with Federal Highways (FHWA) and Federal Railways (FRA) for the Columbia River. The Department of Transportation is currently reviewing the need for nationwide expansion of the service to meet other terrestrial users' requirements.

You'll also see in this edition that NAVCEN has been involved in a few other major initiatives as well. Commandant (G-SCE) and the Electronics Engineering Center (EECEN) have begun to deploy the Loran Consolidated Control System (LCCS) over the past few months. LCCS was proposed several years ago to upgrade the Loran control station technology and allow reduced staffing. It is being implemented this spring and summer, to consolidate control of the entire CONUS Loran network at NAVCEN and NAVCEN Detachment. A reduction of some thirty billets accompanies this consolidation. The system has been implemented in phases for field testing by existing control personnel at Loran Stations Middletown and Malone over the past few months. This summer it will enable NAVCEN Det to take over Middletown's control functions and NAVCEN to take over Malone's and Seneca's. The draft 1996 edition of the Federal Radionavigation Plan indicates that we will continue operating Loran until December 31, 2000, and LCCS will help us do that—more efficiently.

You'll also see several articles on Omega. This worldwide radionavigation system, overseen by NAVCEN but operated by the United States and six partner nations, will cease operations on September 30, 1997. NAVCEN's Omega personnel are assisting the Headquarters project officer, Mr. Stew Shoulta (staff member in G-OPN-3), in termination activities. NAVCEN drafted OFCOs to cease operations at the two Coast Guard Omega Stations and to cease oversight and support of the stations operated under six bilateral treaties. Additionally, NAVCEN is preparing a "recognition plan" to properly commemorate the end of an era—Omega was the world's first internationally operated, worldwide radionavigation system.

Finally, all of these changes have required some attention to detail on the home front. NAVCEN has reorganized to accommodate the new functions above and to prepare to eliminate its Omega responsibilities. We have also begun an effort to consolidate the DGPS watch with the Navigation Information Service (NIS) watch in one consolidated operations center. This project will be complete by June, in time to accommodate the LCCS watch. We have planned the operations center to also house the Boating Safety Hotline (USCG Infoline) operators and the NAVCEN communications center.

Clearly there are exciting changes taking place in radionavigation systems today. I've only touched on a few of them—the ones that are affecting NAVCEN most right now. There are other activities, as you'll note in the articles in this Bulletin. Specifically, the Civil GPS Service Interface Committee (CGSIC) continues to be very active—it has contributed to many beneficial changes in GPS to meet civil users' requirements. The NIS continues to grow in importance as a key part of the Coast Guard's delivery of navigation services to the public. Local Notice to Mariners (LNM), GPS, DGPS, Loran, and Omega status and plans, interference reporting, and general navigation information to, and feedback from, the maritime public result in some 100,000 hits per week on the NAVCEN home page on the world wide web (www.navcen.uscg.mil). More on these exciting developments in the next edition of the Radionavigation Bulletin.

CAPT James T. Doherty
Commanding Officer, USCG Navigation Center

LORAN CONSOLIDATED CONTROL SYSTEM

The Coast Guard Electronics Engineering Center is developing the Loran Consolidated Control System (LCCS) to reduce personnel and Loran system operating costs. LCCS will also replace the aging and outdated Loran equipment currently in use. The projected savings from LCCS implementation is $1.1 million per year. In addition, this entire Loran equipment upgrade will be transparent to the Loran user!

As a part of implementing LCCS, the Coast Guard is moving three of its four Loran control stations. The control station at Middletown, California, will move to the Navigation Center Detachment at Petaluma, California. The control stations at Seneca, New York, and Malone, Florida, will be combined at the Navigation Center in Alexandria, Virginia. LCCS will reduce by half the number of watchstanders required to control the Loran system in the lower 48 states resulting in a significant personnel cost savings. The Loran transmitting stations which currently host these control stations have 15 to 20 crew members on board and will be reduced to 4 to 5 personnel when LCCS comes on line.

WHAT IS LCCS?

LCCS is essentially a computer with 2 touch-sensitive display screens, keyboards, trackballs, a printer, and an uninterruptible power supply. One complete LCCS suite fits comfortably in a single workstation module. This replaces a room full of equipment consisting of the Remote Site Operating Set (RSOS), the Calculator Assisted Loran Controller (CALOC), the Chain Recorder Set, and the Loran operational teletype system.

A Portion of the Equipment Suite replaced by LCCS

The computer memory and storage capabilities of LCCS will eliminate the need for paper charts, ink pads, rubber stamps, and chart pens. LCCS is a significant step toward paperless watchstanding.

The LCCS equipment combines the control suite functions of two Loran chains into a single suite of equipment. It will also automate most routine jobs and help the watchstander diagnose Loran chain malfunctions. With LCCS, one watchstander will be able to do the job assigned to 2 watchstanders using the old equipment.

LCCS operates in two modes, either manual or automatic. In manual mode, it analyzes the information received from the transmitting and monitor stations. When LCCS detects a problem, it alerts the watchstander with both visual and audible alarms. When the watchstander responds, LCCS provides a recommended course of action to correct the problem. In automatic mode, LCCS alarms and then acts to correct the problem. If the problem is beyond LCCS's ability to correct, it informs the watchstander.

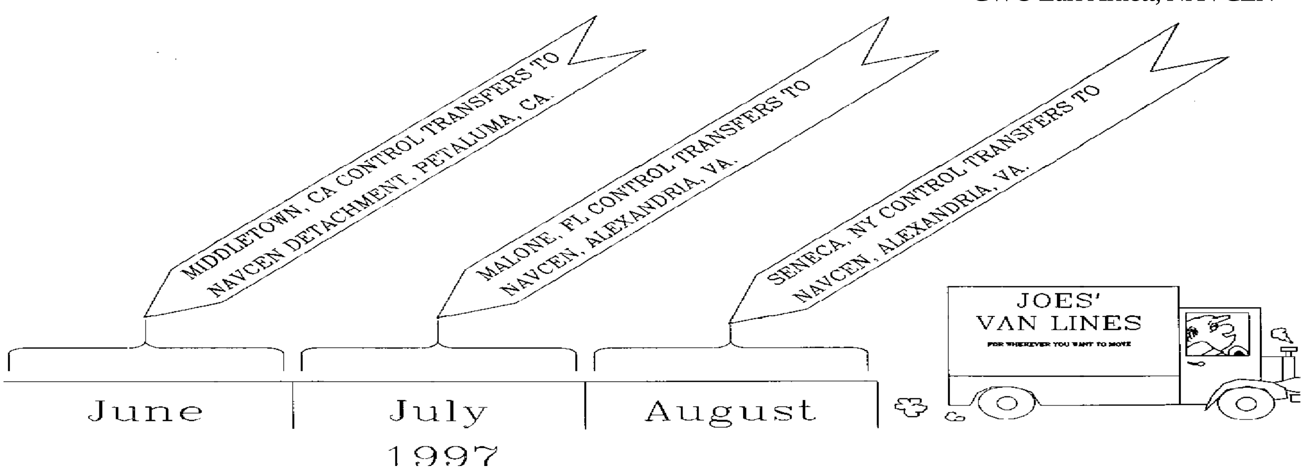
LCCS makes it easier for a watchstander to diagnose and immediately respond to detected Loran chain malfunctions. By touching the image on the screen, a watchstander can switch between a display of the entire Loran chain or to an individual Loran transmitting station or to a Loran monitor station. Entering comments on the tracking charts or in the log is quick and easy. All commands are a mouse touch or two away. Clear, easy-to-read screens present all the information needed for proper operational control of the Loran chain.

LCCS Chain Control Workstation

WHEN WILL LCCS GO INTO SERVICE?

The first LCCS will go into full service in late June of 1997 with the transfer of control station functions from Loran Station Middletown, California, to the Navigation Center Detachment in Petaluma, California. In late July the Navigation Center in Alexandria, Virginia, will assume control responsibilities from Loran Station Malone, Florida. In late August, the Navigation Center will assume control responsibilites from Loran Station Seneca, New York.

CWO Earl Arnett, NAVCEN



Where is the Federal Radionavigation Plan 1996?

Hopefully this spring we'll have it. Several issues are still under discussion between the Dept. of Defence & the Dept. of Transportation. When published, it will be available from the NIS (see NIS on page 11).

Coast Guard Differential GPS: Status and Plans for the Drive to FOC

As CAPT Doherty mentioned in his opening remarks, a lot has happened since January 1996, when Transportation Secretary Peña launched the Coast Guard's DGPS system into the Initial Operational Capability (IOC) phase. Additional sites have been constructed and the Coast Guard is moving aggressively to Full Operational Capability (FOC).

A quick status report shows 53 sites providing monitored DGPS signals. Communications with the Puerto Rico site were established and the Key West site was completed. Several more sites are expected this year. First, in a cooperative effort with a Federal Railroad Administration pilot project for positive train separation, the Coast Guard is establishing a prototype site near Appleton, WA. DGPS equipment should be installed and operating by the end of April 1997 for a one-year test period. The US Army Corps of Engineers is constructing DGPS sites near Omaha NE, Louisville, KY, and Reedy Point, MD. These sites are expected to transmit DGPS signals by the end of 1997.

Let me review the basic requirements of this service which is rapidly becoming an essential utility for many users. As designed, DGPS is expected to be the first federal radionavigation service capable of meeting the 10-meter navigation requirement for harbor entrance and approach. To be a navigation service, the DGPS system must provide four basic features: accuracy, integrity, coverage and availability. Before I continue, some of you may wonder where is reliability? While the latest Federal Radionavigation Plan precisely defines DGPS reliability as fewer than 500 failures/million hours of operation with time to alarm of less than 5 seconds, essentially, reliability of the CG's DGPS system is inherently wrapped up in its ability to provide the other features mentioned.

OK, now back to the four basic features. Accuracy and integrity standards are already met by the current equipment. Users should even note a small improvement in accuracy from a recent reference station firmware upgrade. Where there is signal coverage, DGPS provides accurate corrections with integrity. Yet, as several users have already brought to our attention, the currently deployed system does not provide coverage to all of the expected areas. We are in the process of collecting data to verify the extent of current coverage and expect to complete initial collection by July 97. Initial data collection efforts are focused on areas where coverage is suspected to be marginal. Areas with deficient coverage identified so far are southeast Alaska and southeast Puerto Rico and the Virgin Islands. Additional sites are required to provide the necessary coverage to those regions. The Coast Guard hopes to complete these sites by October 1998.

The DGPS system has two equipment deficiencies which preclude it from meeting availability requirements: transmitters and antenna systems. The Coast Guard expedited entry into the IOC phase by using existing radiobeacons with plans to replace them with new transmitters in the future. Also, many of our non-radiobeacon sites were installed on or near fragile wetlands, and backup generators were not included to speed up the environmental assessment process. Again, intentions are to install new transmitters with battery backup power. Procurement of the transmitters is proceeding well, and we expect to have a contract soon. The battery backup is expected to run the entire suite of DGPS equipment, including the transmitter, for over 20 hours. This feature will greatly improve performance at many sites which are susceptible to frequent, short-term power outages. The other major equipment shortcoming lies with some of the installed antenna systems which are not very resistant to weather. These towers are quite susceptible to dirt, salt and ice buildup and are extremely difficult to maintain. A working group was convened to identify a suitable replacement. A prototype design has been installed at 3 sites in the past 2-6 months with promising results. Replacement of the remaining 23 troublesome antennas will take about a year.

The two replacement projects, transmitters and antennas, are extensive and require considerable funding and engineering efforts to complete. We hope to identify funding and complete these projects by October 1998.

The Navigation Center is also in the process of certifying the operational performance of each site. This is roughly a 2-day job per site. Operational certifications are expected to be completed by the end of 1997.

Now for a quick recap. In order for the DGPS system to achieve FOC, the system must be able to provide accuracy, integrity, coverage and availability. The system already provides accuracy with integrity and, with the new sites and equipment upgrades, it will provide coverage and availability. The only change users will see when the system transitions from IOC to FOC is increased coverage and availability. And finally, the Coast Guard expects the DGPS system to achieve FOC by October 1998.

The Navigation Center's DGPS branch is also involved in some other interesting projects. A natural expansion of the Federal Railroad Administration's Positive Train Separation Project is the nationwide expansion of federally-provided differential GPS, probably based on the radiobeacon datalink system of the Coast Guard. This project is in the infant stages and much work and several important decisions must occur before national expansion becomes a reality. Another NAVCEN project will assess the performance of the latest model of replacement GPS satellite, the Block IIR. Having over 50 sites scattered throughout the United States, we have an excellent opportunity to monitor signal strengths from the new satellite at a number of sites and provide those results back to the Air Force. NAVCEN is also actively involved in coordination of GPS testing and jamming experiments, from ensuring the testing does not interfere with our differential broadcasts to the broader issue of assessing potential disruption of GPS service to mariners.

There are really exciting things happening at the NAVCEN and I look forward to bringing you updates during the next issue. Users are encouraged to visit the NAVCEN's website for information and to submit questions.

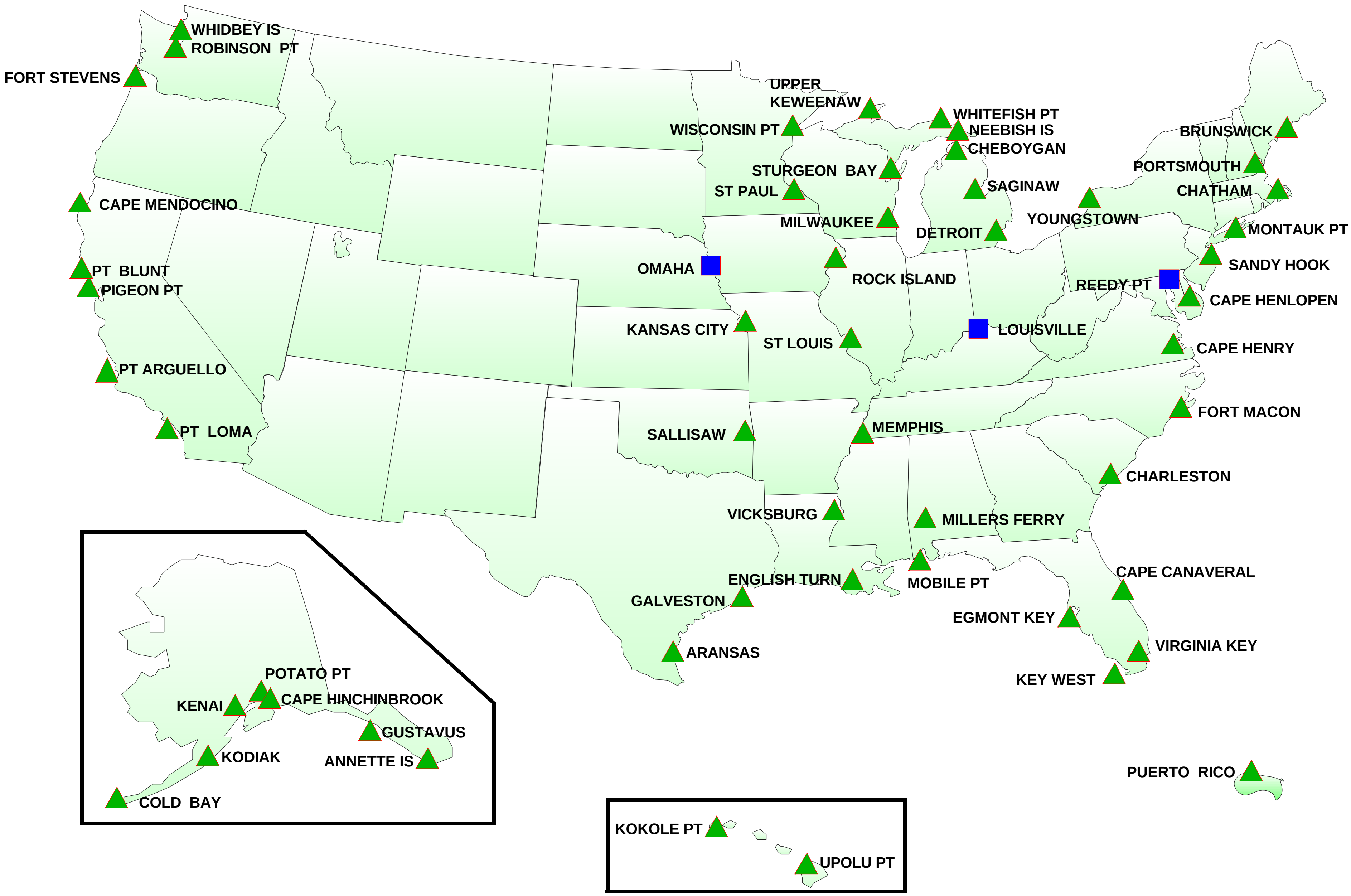
LCDR Gary Schenk, NAVCEN

USCG DGPS SITES

▲ Fully Operational

■ Proposed Future Sites

AS OF 5/1/97



Electronic Navigation Projects at the United States Coast Guard Academy

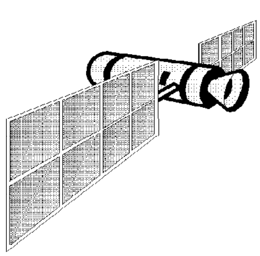
The Coast Guard Academy is continuing electronic navigation research in order to expose cadets to open-ended engineering problems. First class cadets, as part of their senior design course, are teamed with engineers to confront complex navigation problems. Some of the projects are externally sponsored by NAVCEN, Navy Research and Development (NRAD) or the Office of National Drug Control Policy (ONDCP) and may have relatively short term deadlines. Students study fundamental electronic navigation principles, but more importantly they implement and test their system designs in software and hardware. After assessing their results cadets communicate their findings back to the project sponsor. Many of the projects are normally either extensions of a previous year's effort or are a part of a multifaceted project in which cadet contributions are only a fraction of the entire effort. Although not all projects are directly applicable to Coast Guard navigation, the fundamental concepts that cadets master and the skills that they develop are used later throughout their careers as Coast Guard Officers. Some of the navigation projects for the 96-97 academic year follow:

DGPS Antenna Beam Forming and Null Steering

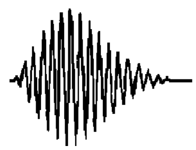
As a proof-of-concept effort for NAVCEN, this project demonstrates that electronic beam forming and null steering improves the signal-to-noise ratio (SNR) of received differential GPS signals in the presence of some localized noise source. A CEI 300kHz, dual magnetic loop antenna is used to receive DGPS signals centered at 293 KHz. The two received signals, one from each loop, are combined to form a figure-8 shaped antenna pattern that is rotated 180 degrees in 5 degree increments. Since we can rotate the main lobe of the pattern, we can also rotate the null in the figure-8 antenna pattern. By rotating the null toward a slowly moving, localized source (e.g. thunderstorm) in real time we can maximize the received SNR. Finding the best angle of rotation can be done empirically or analytically in software. To further improve the SNR using this method, we de-couple the magnetic loops in software which deepens the nulls an additional 20-30 dB.

DGPS Antenna Modeling

Numerical Electromagnetic Code 4 (NEC-4) is used to model various DGPS transmit antennas with top loading elements. One of the modeled antennas is located in Kenai, Alaska. NEC-4 is used to predict the antenna's driving point impedance, efficiency and radiation pattern among many other metrics of interest. The predicted values are compared to measurements taken on site to help verify the NEC-4 model. Future DPGS antenna installations can be modeled prior to construction. Similarly, the U.S. Air Force's Ground Wave Emergency Network (GWEN) 300' antenna in Appleton, WA, is being modeled for NAVCEN and EECEN to evaluate its potential as a future DGPS antenna site.



Magnetic Loop Based LORAN Receiver/Indoor Geolocation



The law enforcement agencies and Department of Defense are interested in the design of a device that transmits the location of personnel inside buildings and in urban canyons. In a 1996 project supported by ONDCP and the British Home Office, the Coast Guard Academy developed a dual magnetic loop antenna based LORAN receiver and ran extensive tests and demonstrations in the urban canyons of London and New York City and indoors at the Academy. Based on these tests, plans are to develop a miniature low power version in FY97 and 98 for urban applications. Indoor military applications require greater accuracy than obtainable from LORAN. In a FY97 project for the DoD, the Academy is developing and testing a very high chipping rate spread spectrum system in the VHF and UHF.

GLONASS Research

There are three phases associated with this project. The first is an evaluation of the Russian Global Navigation Satellite System (GLONASS) time base with respect to Universal Coordinated Time (UTC). Since GLONASS and GPS depend on very precise time measurements relative to UTC, the time base results reflect the accuracy of the GLONASS system. The second phase of this project is to determine the capability of GLONASS, GPS and integrated GLONASS/GPS navigation within an urban canyon environment. An Ashtech GG24 integrated GLONASS/GPS receiver is used to gather data in London and New York City. Results indicate that the integrated GPS/GLONASS receiver increases the possibility of obtaining a fix within restricted visibility environments. The final phase of this project quantifies the minimum signal strength level that is required to receive GLONASS signals inside buildings. Since GPS and GLONASS are designed to be line-of-sight navigation systems, detecting signals within the interior of buildings is very difficult. Very long records of digitized RF from both internal and external antennas are post processed using the data from the external antenna as a reference to remove doppler, code, and data permitting very long coherent integration times on the signal from the internal antenna.

LT David Dermanelian, USCG Academy

ELECTRONIC CHART DISPLAY AND INFORMATION SYSTEMS (ECDIS)

I. INTRODUCTION

In November 1995, the International Maritime Organization (IMO) adopted Resolution A/817(19), Performance Standards for Electronic Chart Display and Information Systems (ECDIS). Initially envisioned as a paper chart equivalent under regulation V/20 of the 1974 Safety of Life at SEA (SOLAS) Convention, ECDIS development has evolved to incorporate advanced technologies to provide a safer, faster, and more efficient method for navigation. There are numerous papers available concerning ECDIS technology and applications. In contrast, few papers exist to document the status of ECDIS implementation. In addition to IMO A/817(19), there are three other publications that serve as guidance for specifications, procedures, and type approval for an IMO compliant ECDIS. The intent of this article is to provide a snapshot of these publications and acquaint the reader with the process for formal adoption and implementation of ECDIS.

II. ECDIS

In its simplest form, an ECDIS can be modeled as:

ECDIS =	***System performance***	+	***Data Format***
	(IMO A/817(19) & IEC 1174)		**(IHO S-52 & S-57)**

IMO A/817(19): Performance Standards for Electronic Chart Display & Information Systems (ECDIS)

IEC 1174: Operational & Performance Requirements:Methods of Testing & Required Test Results

IHO S-52: Specifications for Chart Content & Display Aspects of ECDIS

IHO S-57: IHO Transfer Standards for Digital Hydrographic Data

The system performance is governed by IMO A/817(19) and specified within International Hydrographic Organization (IHO) Special Publication 52 (IHO S-52). The data format is specified by IHO S-57. In addition, the International Electrotechnical Committee (IEC) is developing IEC Publication 1174 (IEC 1174). This publication is intended to serve as guidance for ECDIS 'type approval.'

III. ECDIS PERFORMANCE STANDARD AND RELATED PUBLICATIONS

IMO A/817(19) specifies performance standards for the following components and functions of ECDIS:

- display of information
- provision and updating of chart information
- scale
- display of other navigation information
- display mode and generation of neighboring area
- colors and symbols
- display requirements
- route planning, monitoring and voyage recording
- accuracy
- connections with other equipment
- performance tests, malfunction alarms and indications
- back-up arrangements
- power supply

IMO A/817(19) serves as the regulatory policy governing ECDIS for National Administrations. The latest addition to this document concerns back-up arrangements. This addition was formally adopted by IMO in November 1996 and will become Appendix 6 to the Performance Standards. [1]

IHO S-52 is the IHO Specification for Chart Content and Display Aspects of ECDIS. This document contains two annexes and three separate appendices. The annexes provide a cross-reference between S-52 and the IMO Performance Standard. The appendices provide guidance for updating the electronic nautical chart (ENC), color and symbol specifications for ECDIS, and a glossary of ECDIS related terms. The 5th Edition of S-52 was issued in December 1996. Current revisions to annexes and appendices for this edition of S-52 will be issued in the first half of 1997. [2]

IHO S-57 is the IHO Transfer Standard for Digital Hydrographic Data. This standard was adopted as the official IHO standard at the 14th International Hydrographic Conference in May 1992. The standard includes an object catalog, an ENC Product Specification, and an ENC updating profile. Edition 3 of S-57 was released in November 1996 and will be 'frozen' for three years to provide a stable benchmark for ECDIS product development. When taken in context with the IMO Performance Standards, ENCs must be produced by or on the authority of Official Hydrographic Offices. [3]

At IMO's request, IEC started work in 1992 to identify the necessary performance tests and checks for an IMO compliant ECDIS. IEC 1174 specifies the operational and performance requirement, methods of testing and required test results for an IMO compliant ECDIS. The final draft of IEC 1174 was completed in December 1996 and is undergoing a six-month review process. Final completion of IEC 1174 is expected to occur by end 1997 and formal adoption in early 1998. Once adopted, IEC 1174 will become the basis for type approval for an IMO compliant ECDIS. [4]

IV. SUMMARY

An operational ECDIS must satisfy system performance requirements, have the correct electronic nautical chart data, and be able to pass type approval. It appears that the standards and specifications necessary to support this are becoming a reality. IMO A/817(19), IHO S-52 and IHO S-57 will become stable benchmarks during the latter half of 1997. IEC 1174 is expected to be formally adopted by early 1998. Commercial ECDIS manufacturers will soon have a defined set of standards, specifications, and procedures to guide them in the production of ECDIS hardware and software. National Hydrographic Offices will need to produce or ensure the production of the necessary IMO compliant nautical chart data for these systems. Only by accomplishing these milestones will an operational ECDIS become a reality as we venture into the 21st century.

LCDR Bobby Lam, NAVCEN

(See ECDIS References on page 13)

OMEGA NAVIGATION SYSTEM TO BE TERMINATED SEPTEMBER 30, 1997

During the final minutes of September 30, 1997, another chapter in the history of the U.S. Coast Guard's continuous service to mariners and aviation navigators will come to an end. After more than 20 years of operation, as the first all weather worldwide radionavigation service, the Omega Navigation System will be terminated. Like Ocean Stations, manned lighthouses, and AMVER/CW Monitoring on 500 kHz, rapidly advancing technology will soon cause the Omega Navigation System to become obsolete. The Omega System will be replaced by the more accurate Global Positioning System (GPS), and pass into the rich history of U.S. Coast Guard aids to navigation.

The Omega Navigation System is the culmination of years of research begun by the U.S. Navy prior to World War I. During the experimental phase of Very Low Frequency (VLF) broadcasts, it was discovered that the ionosphere reflected radiowaves back to the Earth. By employing this ionospheric property, a signal from a single station could be received over an immense portion of the surface of the Earth. This allowed for the development of a cost effective system that would provide worldwide coverage with just a few transmitting stations. As a result, the Omega Navigation System has been able to provide continuous, worldwide coverage with a system availability of more than 95% by employing only eight transmitting stations.

Mr. John Alvin Pierce, the "Father of Omega," first proposed the use of continuous wave modulation of VLF signals for navigation purposes in the 1940's. Working at the Radiation Laboratory at the Massachusetts Institute of Technology, he proved the viability of measuring the phase difference of radio signals to compute a location solution. Mr. Pierce originally called this system RADUX. After experimenting with various frequencies, Mr. Pierce settled on a phase stable 10 kHz transmission in the 1950's. Thinking this frequency was the far end of the radio spectrum usable for navigation, Mr. Pierce dubbed the transmission "Omega," for the last letter of the Greek alphabet. Some of his earlier experiments in radionavigation centered on using timed pulses to determine location. Measuring timed pulses required using higher frequency transmissions that penetrated the ionosphere, limiting the range of a single station. This higher frequency system was later perfected and is now known as the LORAN C system.

In 1963, the U.S. Navy selected Mr. Pierce as the chairman of the Omega Implementation Committee (OIC). The committee was established to define the transmitting, receiving, and operational characteristics of a worldwide Omega Navigation System. Due to the high cost of constructing VLF antennas (Omega antenna towers are more than 1200' tall), the first experimental transmissions were actually existing VLF communications stations that were modified for Omega transmissions. Over 31 possible transmitting sites were considered. Eventually, eight locations were established as permanent transmitting stations. The Bratland, Norway station (near the Arctic Circle) and the Haiku Valley station on Oahu, Hawaii, originally experimental stations, were among the first in the system. In 1968, the U.S. Navy authorized full scale implementation of the Omega System based on the OIC report.

Responsibility for the operation was transferred from the U.S. Navy to the U.S. Coast Guard in 1971, under the terms of Title 14, USC 82. The Coast Guard created a new command, the Omega Navigation System Operations Detail (ONSOD) to operate the system. ONSOD control of the synchronization of the system was perfected while the Navy Project Office finished the task of constructing the stations. As construction of the final six stations proceeded through the 1970's, ONSOD assumed the duties of engineering maintenance for those stations as they were declared operational. Eventually, eight permanent stations located in Bratland, Norway; Paynesville, Liberia; Kaneohe, Hawaii, US; Lamoure, North Dakota, US; Plaine Chabrier, La Reunion, France (Indian Ocean); Golfo Nuevo, Chubut, Argentina; Woodside, Victoria, Australia; and Shushi-Wan, Tsushima Island, Japan were completed.

Separate bilateral agreements were negotiated between the U.S. and the six partner nations. ONSOD, later the Omega Navigation System Center (ONCEN), was named the Operational Commander (OPCON) with each partner nation maintaining responsibility for administrative control (ADCON). The U.S. owns and maintains all the Omega-related equipment at each station. The host nation provides personnel, funding and non-Omega support for the station. Partner nation crews come from military and civilian sources. The Argentine and French stations are crewed by both military and civilian members of their respective Navies; the Japanese station is crewed by uniformed members of the Japanese Maritime Safety Agency, while the Australian station is crewed by civilian employees of the Maritime Safety Agency (equivalents of the U.S. Coast Guard); and the Liberian and Norwegian stations are crewed by civilian government employees.

It takes a tremendous effort, on the part of Team Coast Guard, to provide the system with world-class support. The organizations involved in this unique international system include Commandant (G-OPN-3); CG Navigation Center (NAVCEN), the current OPCON; Engineering Logistics Center (ELC) Baltimore; Electronics Engineering Center (EECEN); Civil Engineering Unit (CEU) Cleveland; Civil Engineering Unit (CEU) Honolulu; CG Finance Center (FINCEN), Chesapeake, VA; the Eighth Coast Guard District, New Orleans, LA; and the Fourteenth Coast Guard District, Honolulu, HI. Throughout the history of the system, CG Personnel have distinguished themselves by finding innovative ways to deal with the ever-changing international environment in which they must operate. Whether they were called upon to ship a transformer to Liberia on short notice, arrange helicopter support to replace damaged components of an antenna high above the valley floor in Hawaii, or contract maintenance for the antenna in Argentina, U.S. Coast Guard personnel have always risen to the challenge and helped set the standard for radionavigation reliability.

By receiving signals from three stations, an Omega receiver can locate a navigator's position to within 4NM. Mariners using Omega are able to accurately fix their position on the high seas when poor weather conditions preclude celestial fixes. Aviators are able to plan Great Circle routes without regard to the location of Ocean Station positions, and extend their flight distances. If you have taken a commercial flight to Hawaii or Bermuda, or taken a transoceanic flight in the past 20 years, the aircraft you flew on most likely used Omega as the primary enroute navigation system.

Even though the Omega System was originally designed exclusively for navigation, enterprising individuals have ingeniously employed Omega signals wherever they can be received on the face of the Earth. Collateral benefits have extended beyond the imagination of anyone involved in the development and operation of the system. Weather observers and forecasters are able to track weather balloons using Omega signals and can accurately predict weather patterns. This tracking ability greatly increased the reliability of hurricane path predictions. As a result, advance notification of landfall of hurricanes was increased from minutes to hours, thereby giving potential victims time to save their lives and property. Since Omega transmissions are controlled by highly accurate atomic clocks, and timed to within nanoseconds of each other, users with precise timing needs could rely on Omega signals to provide exact timing benchmarks at any location in the world. One of the more innovative uses of Omega signals was devised by seismologists studying earthquakes. Simply knowing the precise time when a seismic shock wave arrived at a monitor station, and correlating that time with other monitor stations, a seismologist could determine the exact epicenter of the earthquake.

As remarkable as the individuals who developed Omega were, the operators of the system have proven to be an equally extraordinary group of dedicated professionals. Despite operating in some of the most remote corners of the earth, the crews at Omega transmitting stations have maintained an unparalleled record of success. Consistently operating well above the advertised goal of 95% availability, the stations have been able to provide high quality signals more than 99.93% of the time. The U.S. Coast Guard has operated the two U.S. stations since the early 1970's. The difference between the locations of the two stations mirrors the wide diversity of the 6 internationally operated stations. OMSTA Kaneohe is located on the north shore of an island paradise, Oahu, Hawaii, in sight of some of the best surfing in the world. OMSTA Lamoure, North Dakota, is located over a thousand miles from the nearest ocean. It is truly an amazing sight to see members of the world's premier maritime service, working to provide essential navigational guidance to mariners, from near the geographic center of North America.

Appropriately, a nation with one of the largest merchant fleets in the world operates an Omega station. On the west coast of Africa, OMSTA Liberia has twice withstood civil wars, looting and outright attacks, only to rise like a Phoenix from the ashes, to resume transmissions. As a result of the attacks, the crew has operated the station under the protection of the East African Community Military Observation Group (ECOMOG). A platoon of infantry, and an ECOMOG tank, have been deployed at the station to deter acts of violence against the facility, since 1992. In the early 1990's, during an extended period of civil unrest, more than 26,000 refugees sought sanctuary under the umbrella of the Omega antenna. The promise of safety might have been brought about by the knowledge that, amidst the death and destruction of the civil unrest, the Omega antenna was the symbol of a beacon to the world. Silently guiding ships and planes safely to their destinations, this symbol of the outside world, forged a tenuous link between international travellers and this tiny war-ravaged country.

Far to the north, in Norway, a much different battle transpires every day. The crew of OMSTA Norway labors against the relentless Arctic Cold, long winter nights that give way to fleeting moments of daylight, and the grinding isolation only the residents of the Arctic tundra could explain. Operating in one of the harshest environments on the face of the earth, OMSTA Norway has proven to be among the most reliable stations in the system. This crew, just a small part of the international Omega team, has proven that there is no way to keep an Omega station off the air for very long.

The Omega Navigation System has meticulously served the needs of navigators, numbering into the hundreds of thousands, over the past 20 years. By employing new technologies, the operating agencies involved with the system have been able to reduce their staffs to minimum numbers, and kept their collective annual costs to less than $15M U.S. dollars. Despite all this, Omega is in the twilight of a long and successful run. Mr. Pierce, warning of complacency in achievement, wrote in 1989:

> The feeling of triumph [one] enjoys when he has reached the end of a difficult course may itself be enough to blind him to any further advance that might be possible. In a foot race, or when killing an enemy, a clear end can be distinguished. But in most activities in life, every achievement is usually only a step on a long path. (Excerpt from "NEVER STOP THINKING" by J. A. Pierce)

The sun is now rising on a new era in radionavigation, and it is the Global Positioning System's time to pick up the baton. The tradition of dependability has been set by its radionavigational ancestors. The navigators of the world deserve, and will get, no less than the excellence that they have come to expect from U.S. radionavigation systems.

LT Kenneth Pierro, NAVCEN

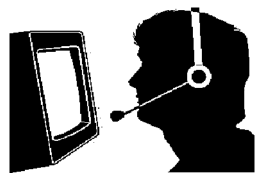
The DGPS Watchstander

A DGPS watchstander is very similar to being a Maytag repairman, you are ready to spring into action at the slightest hint of trouble. As an Electronics Technician this job requires more brain than brawn. Being a rocket scientist is a definite plus when it comes to understanding GPS and DGPS theory, but is not a requirement for the job. What follows is a description of how I carry out my duties as a DGPS watchstander.

Prior to assuming the watch I check the current GPS satellite status to be aware of any coverage outages that may occur during the day. Next I look at the Differential Broadcast Site Monitor (DBSM) display, which is a map of the United States and Puerto Rico, with an overlay of all the DGPS sites. The DBSM monitors the physical conditions at a site and alerts me when it detects a change in status. These conditions include high and low temperature alarm, intrusion alarm, loss of primary power, and equipment currently on-line. After ensuring all is well, according to DBSM, I take a seat at the heart of the Differential Global Positioning System, the Control Station.

In front of the Control Station I am the master of all I survey. At my finger tips are two Hewlett Packard UNIX computers. I have the capability of switching site equipment from side A to side B, and powering up or powering down the equipment. I can also query each Integrity Monitor and Reference Station for such information as beacon signal strength, number of satellites being tracked, radial position error and any other data critical for signal and accuracy analysis. Another tool at my disposal is the Control Station Data Analyzer. This software allows me to print detailed plots of signal strength, signal to noise ratio, and message error ratio. I also handle numerous calls from the public, mostly asking when and where the next DGPS site will be constructed.

Suddenly a red alarm flashes on the 35 inch auxiliary monitor "HIGH POSITION ERROR". I instinctively request confirmation from the standby Integrity Monitor. Data from the standby equipment confirms that the DGPS signal has exceeded the 10 meter tolerance. I wield my mighty trackball feverishly clicking menu commands to resolve the problem. I can then stand down from the alarm condition, secure in the knowledge that accurate corrections are once again being transmitted. My victory is short lived though as another alarm comes across: "ZERO BEACON SIGNAL". Once again I cross check this alarm with the redundant equipment at the failed site when suddenly an attention beep from DBSM is all the confirmation I needs. The status screen on DBSM tells me the radiobeacon has indeed failed. Unable to restore the site remotely, I am forced to call in the local technicians. After the technicians have been notified, I turn my attention toward letting the public know about the outage. First, I select the proper menu so the type 16 RTCM message can be accessed. This message type allows me to input a plain text message which will be transmitted by the adjacent sites. This message will then be received and displayed by the users' differential receiver. Next I request a Broadcast Notice to Mariners (BNM) from the Navigation Information Service (NIS) watchstander, also located at the Navigation Center. The NIS will issue the actual BNM, alerting vessel traffic to the DGPS outage in that area.



And this is a typical day in the life of a DGPS watchstander.

Electronics Technician 1st Class Damon Raley

Navigation Information Service (NIS)

Write to:
Commanding Officer (NIS)
US Coast Guard Navigation Center
7323 Telegraph Rd
Alexandria VA 22315-3998
Telephone: (703) 313-5900
Fax: (703) 313-5920

Contact the BBS, call:
Telephone: (703) 313-5910
Modem speeds of 300 to 28,800 bps & most comman U.S. or international protocols are supported.
Communication parameters: 8 data bits, No parity, 1 stop bit, asynchronous comms, full duplex.

Internet:
http://www.navcen.uscg.mil
ftp://ftp.navcen.uscg.mil

E-mail:
nisws@smtp.navcen.uscg.mil

Fax on Demand (FOD):
Navigation Information 24 hours a day at:
Telephone: (703) 313-5931/5932

NIS 24-Hour GPS/OMEGA Recording:
GPS: Telephone (703) 313-5907
OMEGA: Telephone (703) 313-5906

WWV/WWVH Radio Broadcast:
WWV broadcasts by telephone or radio at 14-15 minutes past the hour and WWVH at 43-44 minutes past the hour.
Radio frequencies: 2.5, 5, 10, 15, 20 MHz
Telephone: (303) 499-7111

Boating Safety Infoline:
Get information on boating safety recalls. Report possible defects in boats. Comment on USCG boarding procedures. Get boating safety literature & answers to questions.
Telephone: (800) 368-5647

WIDE-RANGING SIDE EFFECTS OF OMEGA

The impact of the discontinuation of Omega in 1997 will affect not only those system users directly involved in navigation, tracking, and timing, but others as well. Because of their prominent antennas and interesting mission, many Omega stations are recognized in their local areas as major tourist attractions, including official listings and pictures in area tourist brochures. Omega station North Dakota is located in the town of La Moure, with a population of less than 1000. Within this small town is located the Omega Motel, the Omega Plaza, and the Omega Room at one of the restaurants. Omega Station Norway has a prominent sign along the road near the helix building proclaiming their antenna as the longest antenna span in Europe. The Japan tower is the highest structure in Japan, and the Argentina and Liberia towers are the tallest structures in their entire continents. Australia registers over 10,000 visitors per year to its station. Once Omega is terminated and the facilities demolished, these attractions will no longer exist. And someday people will wonder why all those places in southeast North Dakota are named Omega.

Mr. Robert Hoyler, NAVCEN

Reduced Costs for "Omega-Like" Systems

Despite the impending termination of the Omega Navigation System on September 30, 1997, there is still a lot of interest by a variety of users for continuing VLF navigation. In the U.S. alone, several organizations have suggested such an interest, even though individually they could not justify supporting the entire OMEGA system. Organizations which have expressed interest include: U.S. Navy submarine polar operations, U.S. Navy P-3 operations, U.S. National Weather Service, NATO-AWACS, some major and smaller airlines and charter operators, scientific users such as wildlife tracking on both land and sea, and scientific researchers in VLF ionospheric propagation. Some potential ongoing users have indicated that although it would be beneficial to them if the system were to continue, the benefits would not justify bearing the entire expense on their own, and therefore they would need to seek alternative solutions.

Although the Omega system, as it is known today, (eight transmitting stations in and supported by seven Partner Nations, coordinated by the U.S. Coast Guard, and overall synchronization by the Japanese Maritime Safety Agency) will likely end on schedule this coming September, there are some significant areas of investigation that could be explored by any organization or group of organizations wishing to continue their capability for VLF navigation or tracking. The major benefits of VLF navigation are predictable worldwide propagation, propagation under the surface of the Earth (both land and sea), extremely low cost receivers (making "throwaway" units economically feasible), and relatively low overall system cost.

Despite OMEGA's already relatively low cost, an "Omega-like" system could be even less expensive to operate. Cost reductions could be realized in three basic areas:

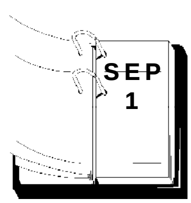
1. Reduced transmitted power. Electric power is one of the two biggest costs items at an Omega station. Actual measurements have shown that OMEGA signal strength levels on the Earth's surface are higher than were predicted by the original theoretical calculations on which the transmitted power requirements of 10KW were determined. Early experimental tests showed good results with transmitted power levels of less than 1/10 of present levels. Also, receivers are more sensitive now than they were in the 1960s when the transmitted power levels were determined. In addition to directly reducing power costs, reduced transmitted power also increases equipment reliability and reduces maintenance costs. Power costs could easily be reduced by at least a factor of two with no unacceptable operational effects.

2. Reduced personnel. Personnel costs at Omega stations is the other of the two biggest costs. Techniques to reduce staffing include reducing power requiring less maintenance personnel, allowing longer MTTR (eliminates need for full-time staffing), simplifying synchronizing techniques (now possible using GPS), and expanding use of remote monitoring/control. The new timing and control equipment allows for additional automation. A reduction by at least a factor of 2 should be possible with no problem. Present Omega stations operate with staff sizes ranging from 30 at Liberia to 5 at Australia, with an average of about 16. It is conceivable that at least some of the stations could even be totally unattended, resulting in major reductions in personnel costs.

3. Reduced coverage. For limited coverage, the present 8-station system could be reduced to a minimum of 3 to 4 stations with one acting as a backup.

If cost reductions of the type described were implemented, it could make it economically feasible for one or more organizations to continue operation of a modified "Omega-like" system.

Mr. Robert Hoyler, NAVCEN



The deadline for article submissions for the next Radionavigation Bulletin is September 1, 1997. Please see "Contributers" on page 1.

While stationed overseas as the Coordinator of Chain Operations for the Mediterranean Sea Loran-C Chain, I conducted a contest in our monthly Activities Europe Newsletter to find the best story describing Loran to our non-radionavigating relatives back home. The target audience was our typical "Aunt Judy" whose technical background is limited to recording prime time TV programs. SN Don Hunley, one of the control station watchstanders, won the contest with this captivating story below.

LT Jim Elbe, NAVCEN

*L*UNAR *O*RBITATIONAL *R*ADIOWAVE *A*LTITUDE *N*ATURALIZATION

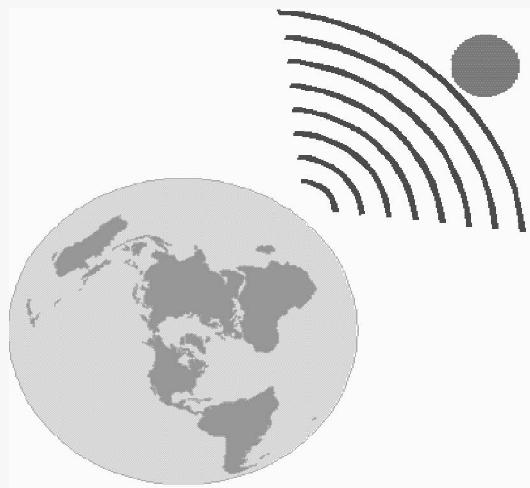
by Don Hunley

Between 1939 and 1941 some of the nations leading scientists expressed early concern over the unprepared state of U.S. military technology. As their collective concerns grew, they eventually formed the National Defense Research Committee BLAH, BLAH, BLAH.

That version of the story is great if you want to be spoon-fed an obvious falsity. This lie was concocted by the super powers in an attempt to keep children from waking up in the night screaming and sweating about the real truth.

The truth is as follows.

In early 1935 select high ranking officials in several of the world's most powerful countries were contacted by a race of beings from a planet outside our solar system. These officials were informed that the gravitational orbit of our moon was being affected by forces that would lead to its eventual collapse and the moon would fall directly into our planet. The stellar positioning of Earth provides a reference point for these beings and is therefore of value to them. If Earth were taken out of its position by violent contact with the moon the result would have a negative effect of the navigational capabilities of these creatures.



Several attempts were made to perfect a system to retain the gravitational field of the moon but the scientists of Earth were in a primitive stage of advancement and the aliens agreed to provide a system and teach us to maintain it. By emitting a series of pulses we are able to stimulate the moons gravity field, much like stimulating a human muscle with low voltage electricity. The signal that we produce strikes the moon at calculated angles and induces a turning effect. As the moon turns it builds a stable gravity field and is able to maintain its current altitude and position.

The acronym LORAN does not stand for Long Range Aids to Navigation but Lunar Orbitational Radiowave Altitude Naturalization. The procurement of this information was not without its price. Myself and many others underwent arduous physical and mental torture in pursuit of the truth. Do not let this sacrifice be in vain. The aunty Judys of the world deserve to know the real story.

Go forth and speak the truth. LORAN is saving our planet.

ECDIS References from page 8

1 International Maritime Organization, " *IMO Resolution A/817(19),*" November 1995

2 International Hydrographic Organization, " *IHO Special Publication 52, Edition 5,*" December 1996

3 International Hydrographic Organization, " *IHO Special Publication 57, Edition 3,*" November 1996

4 International Electronic Commission, " *IEC Publication 1174 (CDV),*" March 1997